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MINING METHODS AT MINAS DE MATAHAMBRE, MATAHAMBRE, PINAR DEL RIO, CUBA.

BY

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MINING METHODS AT MINAS DE MATAHAMBRE, MATAHAMBRE, PINAR DEL RIO, CUBA [1]

By George L. Richert[2]

INTRODUCTION

The Minas de Matahambre is situated on the north coast of Cuba, in the Province of Pinar del Rio, approximately 150 miles west of Havana. This mine is the only producer of copper in Cuba, and has been worked for the past 15 years. In 1921 the property was affiliated with The American Metal Co., Ltd., and has been worked by them since that time under the direction of Mr. D. D. Homer, General Manager.

Extracts from P. D. Wilson's "Preliminary report on the geology at Minas de Matahambre" have been freely used in this report.

GEOLOGY

The main mountain range in the Province of Pinar del Rio, the Sierra Organos, parallels the coast in a northeasterly direction a few miles south of Matahambre. The district itself is in a comparatively low, outlying, parallel range, composed entirely of sedinmentary rocks - shale and metamorphosed sandstone - of which a great thickness is exposed. Mineralization is found at various points in this range of hills for a distance of about 14 miles. No igneous rocks have been recognized at or near Matahambre.

Although there is not a great deal of vegetation, except in some of the arroya bottoms, the surface is normally covered with thick deep grass. Two or three feet of loosely cemented talus and detritus usually cover the hill slopes, so that outcrops in place are hard to find, even where the grass has been burned or worn off. Rock exposed in gulch bottoms and the rather infrequent projecting knobs and areas of more resistant material are all that are available for surface study. The hillsides are usually gently sloping, but some of the gulches are steep-sided, indicating recent rapid erosion by the torrential rains of the wet summer season. The high humidity of the six months during the summer and the rapid run-off and erosion have resulted in complete but rather shallow oxidation and unimportant secondary enrichment of the sulphide ore bodies.

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[1] The Bureau of Mines will welcome reprinting of this article, but requests that the following footnote acknowledgment be used: "Printed by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.)"

[2] One of the consulting engineers, U. S. Bureau of Mines.

In one of the steep gulches, where the original discovery at Minas de Matahambre was made, rare residual primary sulphides may be found in the actual outcrop, mixed with copper carbonates and oxides, a little sooty chalcocite, and porous, cellular iron oxides. This is the only place where even stains of copper have been seen on the surface. Very complete oxidation extends in places underground to a short distance above the fifth level, a maximum of 200 feet below the surface. Important primary ore bodies with irregular sooty chalcocite pockets and layers were mined on the fifth level, but no definite extensive secondarily enriched zone between the chalcopyrite of the primary ore and the almost copper-free leached limonite gossan above appears to have existed.

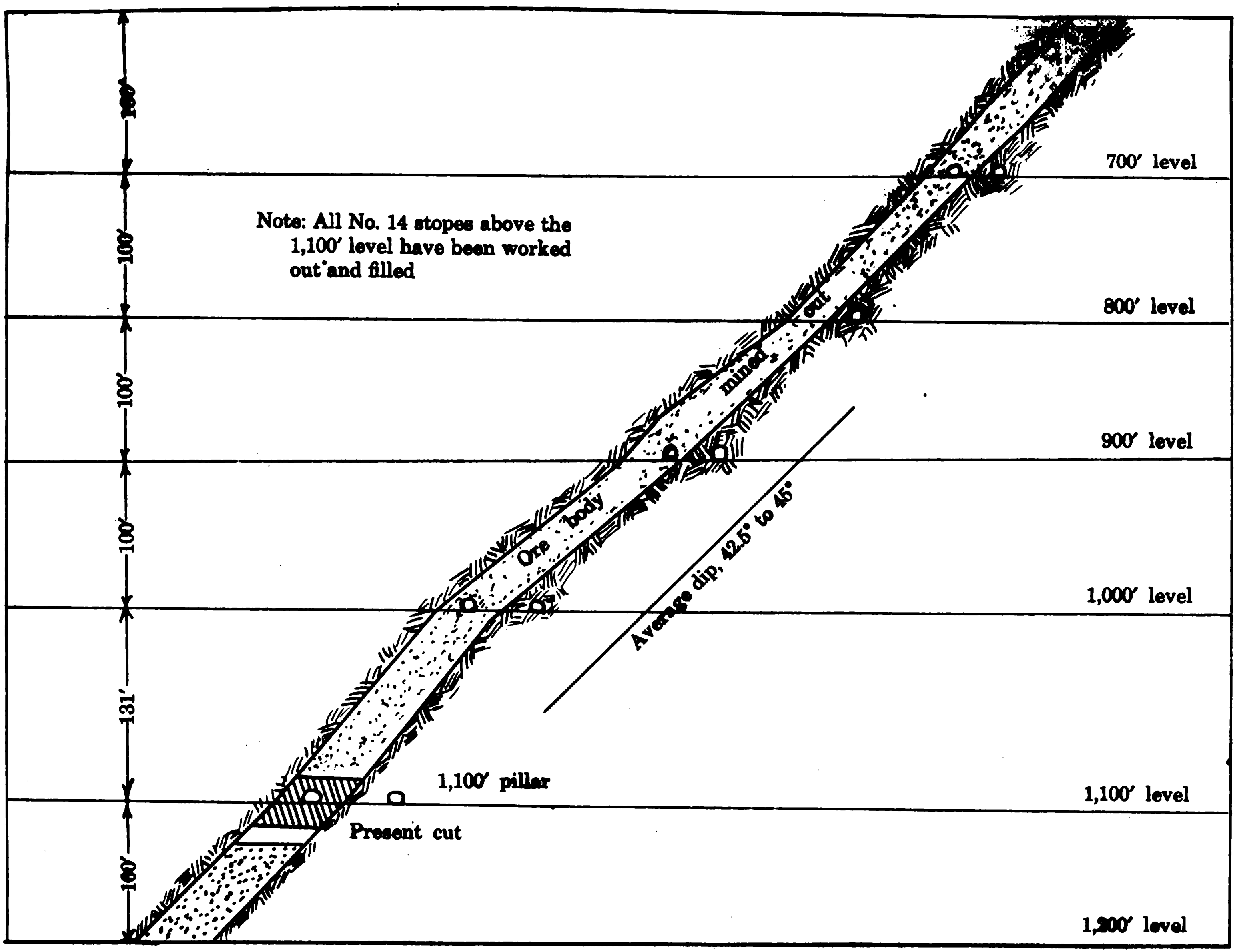
The mineralization at Matahambre is definitely related to fissuring, whic almost always cuts across the bedding. Only locally has it been influenced by t bedding structure, and rarely does ore make off along favorable beds for any distance away from the zone of fracturing. The ore which follows bedding is of mino importance to that which occurs in the fissure zones. On none of the fissures ha there been much movement, and most of that probably took place in the period of postmineral readjustment.

While no intrusive rocks have been found in the region, it is highly probable that the fissuring was induced by highly compressive stresses developed during the cooling of the igneous rock that surely exists at depth and is the source of the mineralizing solutions.

PHYSICAL CHARACTERISTICS OF ORE AND ENCLOSING ROCKS

The ore bodies in the Matahambre mine occur as large irregular pipes, usually with lenticular cross section, of primary chalcopyrite locally associate with quartz and pyrite in three well-defined mineralized fracture zones. The ma mineralized fracture zone, in which the most important ore bodies are found, trends N. 30° E. and dips 42 to 45° northwest. Figure 1 is a cross section of No. 14 ore body, and Figure 2 is a progress map of the 1,300 foot level showing the shape of the ore bodies. The other two zones, about 1,200 feet apart and at each end of the main zone, strike northwest and dip steeply northeast. At Matahambre, ore has been found in sedimentary rocks of a total thickness of over 1,600 feet.

In all Matahambre ore bodies, especially those of larger size, the footwall is usually quartzite and the hanging wall is thin-bedded shale. The footwa will stand well and gives no trouble. The hanging wall, because it is naturally weak and because of the dip of the ore bodies, will not stand for any length of time if exposed for any distance and at a height of over 10 feet. This characteristic of the hanging wall of the ore bodies, together with the rather flat dip, definitely fixed the method and procedure of mining the stopes; namely the cut-and-fill system, with cuts of small height.



Note: All No. 14 stopes above the 1,100′ level have been worked out and filled

Figure 1.– East-west cross section of No. 14 ore body above 1,200-foot level

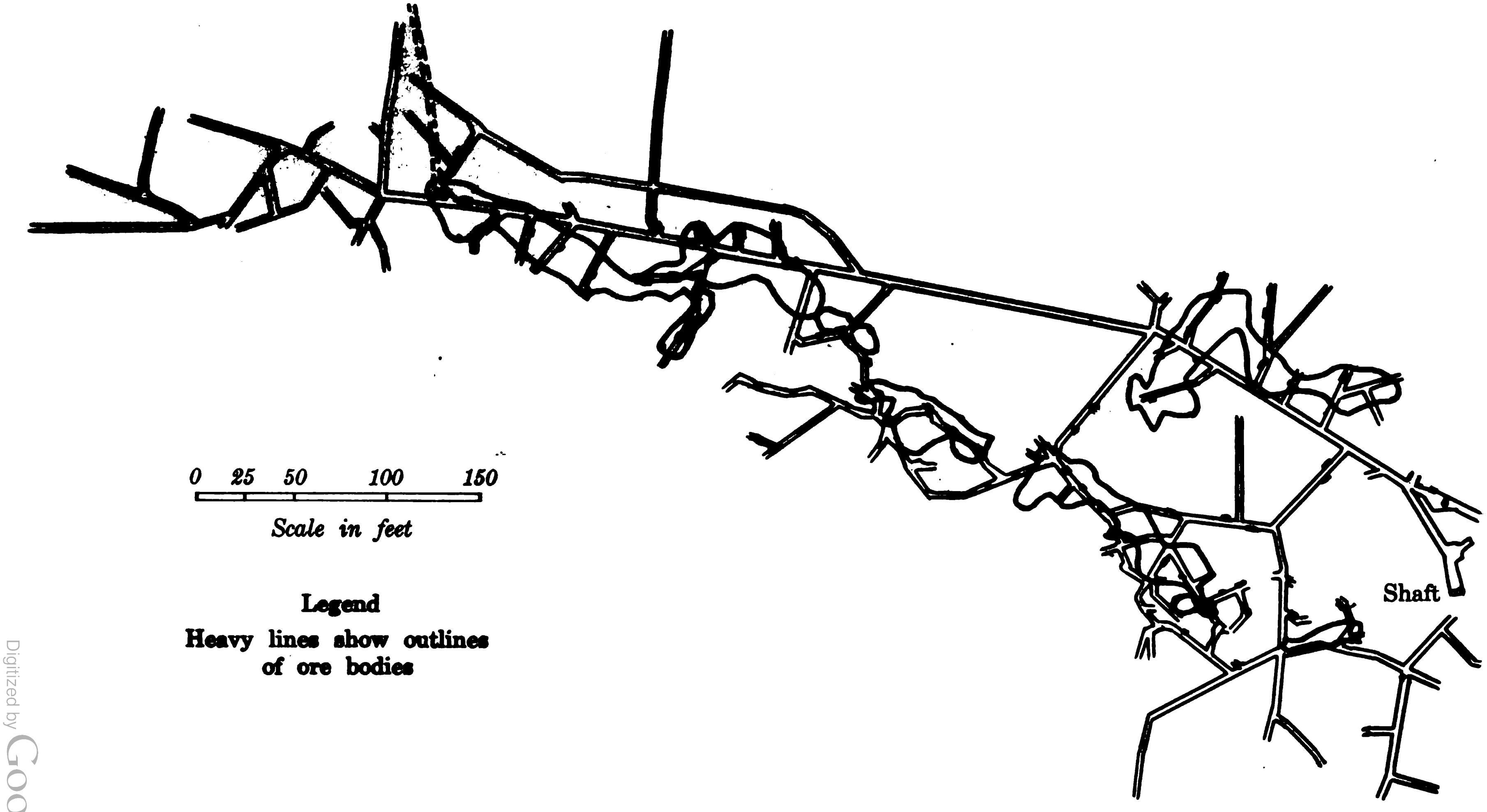


Figure 2.— Progress map of 1.300-foot level, showing outline of ore bodies and development

METHODS OF PROSPECTING AND EXPLORATION

As the dip of the main ore bodies is comparatively uniform, they can be projected with more or less accuracy from one level to the next. However, there are a number of small ore bodies, apparently offshoots of the larger ore bodies, which were found only by prospecting "likely country." At present, prospecting is carried on by diamond drilling, "deep-hole drilling," and by stope and level drifts and crosscuts.

Diamond drilling is carried on both from the surface and underground. On the surface, diamond-drill prospecting consists of drilling on the hanging-wall side of promising outcrops. As the outcrops have as a rule been thoroughly leached out so that only iron stains are left showing at the surface, the holes are drilled at such a distance from the outcrop that they should intersect the ore about 300 feet below the surface. As most of the large ore bodies did not outcrop on the surface, a number of holes were drilled where a prominent ridge or deep sharp ravine indicated faulting or possible movement.

Underground diamond-drill holes are put out where there is some indication of ore - stains or low-grade ore - not directly connected with a known ore body. These holes are as a rule flat and from 100 to 400 feet in length. Diamond drilling is also used when a drift or crosscut has opened some new and undeveloped country.

"Deep-hole Drill" drilling, "while comparatively new at Minas de Matahambr has proved valuable in prospecting for ore bodies which have flattened or steepened and have not been found in the locations projected from the level above. The "deep-hole drills" are also used advantageously in prospecting on the levels for possible extensions in the hanging wall or footwall of known orebodies, and are used in the stopes themselves when there is an indication that the stope has narrowed because of intrusions of waste or following false walls. When the ordinary drifting machine is used the average depth of these holes is 60 to 70 feet. With the large machine mounted on two columns, the holes average 150 to 200 feet. There are at present three "deep-hole drills" in use. Two crews use ordinary drifting machines and one crew uses a large special machine adapted to this work.

Stope drifts and crosscuts are used wherever there is a possibility that an apparently poor showing along the side of a stope may widen out or make ore. These drifts and crosscuts are also used whenever there is any question as to whether or not the true hanging or footwall has been reached. These prospects are usually from 4 to 15 feet long and are run after a cut has been taken from a stope and before the stope has been filled.

Drifts and crosscuts are used for prospecting when it is desired to open some new country for prospecting and the distance prohibits the use of drilling.

METHODS OF SAMPLING AND ESTIMATING TONNAGES

There is no regular system of sampling at Minas de Matahambre. After a short time the grade of the ore can be judged fairly accurately by the eye. The exception to this is in the north end of the mine where the ore contains more pyrite than it does in the other parts of the mine. Whenever there is any question as to the grade of the ore, special samples are taken under the direction of the engineering department. If the ore in question is in a stope, channel samples are cut, usually at 5-foot intervals, and an assay plan is made of the stope.

An ore reserve estimate is made every three months. As the ore is of comparatively constant grade, tonnage alone is considered in making this estimate. Three general rules governing the calculation of reserve ore are as follows:

1. A stope silled-out, first cut taken, but having no raise run in ore connecting the stope with the level above, is considered as having no reserve.

2. A stope silled-out, first cut taken, and having a raise run in ore connecting the stope with the level above, but with no ore silled-out above this level, is considered as having a reserve. In calculating this reserve the area of the stope is considered as the base of a cone and the height to the next level as the height of the cone. The reserve is calculated as a cone, the area of the base times one-third the height.

3. In calculating the reserve of a stope silled-out and connected by a raise or raises in ore to the level above, with a stope being silled out on this level above, the average area of the two stopes and the distance between them is used.

A new plan is made of each stope after each cut is taken, and the latest plan is used in calculating the reserve of any stope. The tonnage of ore reserve is calculated on the basis that 11.62 cubic feet of ore in place is equal to 1 short ton. Possible ore and probable ore do not enter into the reserve calculations. Over a period of years the recovery of the estimated ore has been over 90 per cent. The other 10 per cent includes ore lost by caving, ore of too low grade to mine or pinching out, and overestimation. The factor, 11.62 cubic feet per ton of ore, takes into consideration this 10 per cent discrepancy and compensates for it.

METHODS OF DEVELOPMENT AND MINING

The mine, operated by means of one vertical shaft of three compartments, is producing from 13 levels at the rate of 30,000 tons per month. Ore is broken and hoisted on two shifts, while on the third shift supplies and timber are lowered and some ore is hoisted. The shaft, which is timbered, has two hoisting compartments and a manway. The ore is hoisted in 3 1/2-ton skips hung below double-decked cages. The cages are not removed during hoisting operations. A second shaft has been started to handle the ore from the lower levels, as the ore bodies are some distance from the shaft on the present lower levels. The new shaft has four compartments. There are two hoisting compartments, a chippy or man-hoist compartment, and a manway. This shaft will have steel sets instead of timber and, aside from the collar where concrete was used, it will be lined with native hardwood.

The sixth level, which is the first producing level, is 160 feet below the collar of the shaft. With three exceptions, the levels are 100 feet apart. However, after watching and checking up on two levels that are 130 feet apart, it was decided to space future levels at 150 feet. Aside from the extra hazard in driving the long raises to the level above, no difficulty is expected with levels at 150-foot intervals. The development plan of the company calls for sinking the shaft and starting a new level each year.

The general development plan for any one level is as follows: The ore bodies are projected from the level above so that their approximate location is known. Figure 2 shows the development on the 1,300-foot level. After the station has been cut, the main haulageway is driven towards the first ore body. When within 50 or 60 feet of the ore body, a crosscut is started to cut the ore. As the ore bodies lie more or less on a straight line, especially on the lower levels, the main haulageway is in reality a drift. This drift, in the footwall of the ore bodies, extends from the shaft to the farthest ore body. After the crosscuts from the main drift have cut the ore body, drifts are started to follow the ore, with crosscuts at suitable intervals for chutes and manways. On each level one or more raises to serve as manways and a raise or two to serve as ore passes are run to the level above.

DEVELOPMENT DETAILS

Shafts.- The compartments of No. 1 shaft, the present operating shaft, are each 4 feet 8 inches by 6 feet in the clear. The timber used is 8 by 8 inch hardwood which, although extremely heavy and hard to handle, makes excellent shaft timber as it lasts indefinitely, especially when wet. Shaft sinking is done by a local crew of natives. All drilling is done with 48-pound jackhammers. The standard shaft round consists of 22 to 28 holes, 5-1/2 feet deep. Each hole is loaded with five to seven sticks of 40 per cent gelatin dynamite and detonated by means of No. 8 electric, 1 to 10 delay, caps connected to a 110-volt light line. A sinking hoist, placed on the last operating level, handles the men, supplies, and muck for the shaft. Guides are placed in the manway compartment of the shaft below the level of the hoist, and a door to dump the bucket is placed at the station where the hoist is operating. The muck is shoveled into an 18-cubic-foot sinking bucket by shaft muckers using short-handled shovels exclusively. The bucket is hoisted to the level of the hoist and dumped into a car. When about 15 cars have been loaded, they are taken to some level above where the muck can be dumped into a stope for fill.

The new or No. 2 shaft has three compartments, 4 feet 8 inches by 5 feet in the clear, and one compartment 5 feet 6 inches by 5 feet in the clear. The larger compartment will be the manway compartment and will carry all electric cables, air and water pipe, as well as staggered ladders. A contract has been let to sink this shaft 1,800 feet.

Drifts and Crosscuts.- All drifts and crosscuts are nominally 5 by 7 feet. Track is carried on a .5 per cent grade. All drifting and crosscutting is done o contract, and about 10 per cent of the drifts and crosscuts have to be timbered. Timber is placed by men furnished by the company to the contractor. The contractor is paid for the timber placed and is charged for the timbermen furnished to him.

All drifts and crosscuts are driven with medium weight, Leyner-type drifters using 1 1/8-inch hollow round steel with a standard 5° and 15° cross-bit the machine working on a column and cross arm. A drift or crosscut crew consists of four men. The machineman and helper drill the round and blast on one shift, and two men on the other shift clean out the muck. This plan works out in some drifts, but in others three shifts are required to drill, shoot, and muck a round. Such delays are generally incurred in disposal of waste. The mine are generally good workers, but most of them must be taught to run a machine, as they usually have never seen one before working at this mine. The jackhammer is in high favor with the few miners who have worked in Spain, who if not watched will use this machine exclusively. At the slightest indication that something is wrong with the drifter, the miner will take down the bar and drill with a jackhammer. Education of the local miner progresses slowly.

A standar "wedge-cut" round is used with 15 to 18 holes, as hown in Figure 3. Holes are loaded with five sticks, and the cuts have 6 sticks of 40 per cent gelatin dynamite. This round has been found best adapted to this ground there is some difficulty, however, in getting the miners to point the holes as they should.

The miner must use his own judgment in blasting, as one round may be in shale, the next few rounds in quartzite streaked with quartz stringers, and then the next back in shale. The average round is drilled to break about 4 feet, although there are a few of the better miners who consistently pull 5 feet. No trouble is experienced with the steel, because of the excellent blacksmithing on the surface. There are no "tool nippers," each miner bringing in and taking out his own steel. Occasionally some ambitious miner will have a good supply stored away for a rainy day in some out-of-the-way place. It is probable that eventuall the steel will be checked out to the miner as are the machines and tools.

Raises-Standard raises are 5 by 5 feet in cross section. All raises are driven with hand-rotated (dry) stopers using seven-eighths-inch square solid steel. A raise crew consists of one miner and a helper on each shift. A "wedge-cut" rounc is used, drilled to break 3-1/2 to 4 feet. All stulls and staging are brought from the station and are placed by the miner and his helper. As the majority of the raises are fill raises from stopes, requiring no tramming of muck between rounds, good progess is made in all raises. Only about 1 per cent of the raises require timbering. If necessary to timber, 8-inch round cribbing is used, which is also placed by the miner and his helper. In most raises all material is pulle to the face by rope. A rope and the stulls provide the only means of getting up or down until the raise is holed through.

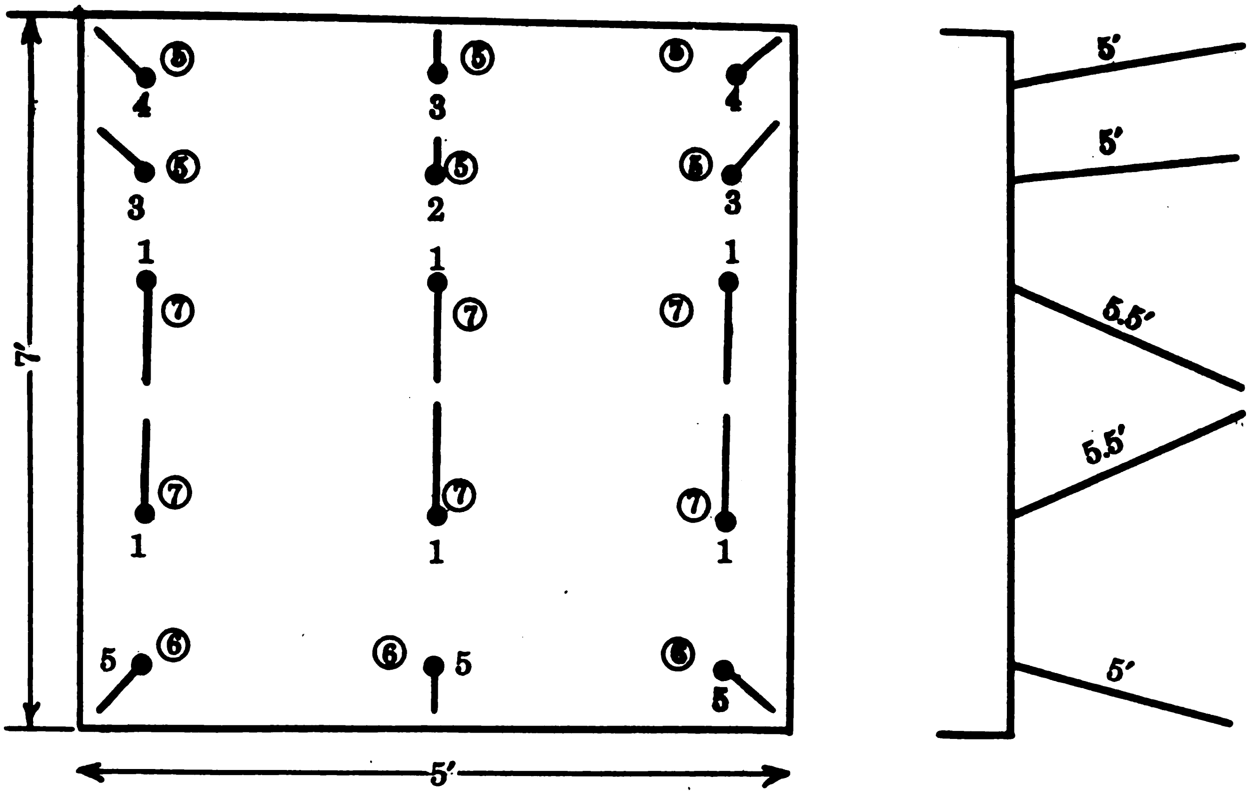


Figure 3.– Drift round.
(From "Drilling and blasting in some American metal mines," by Theodore Marvin.)
Not drawn to scale

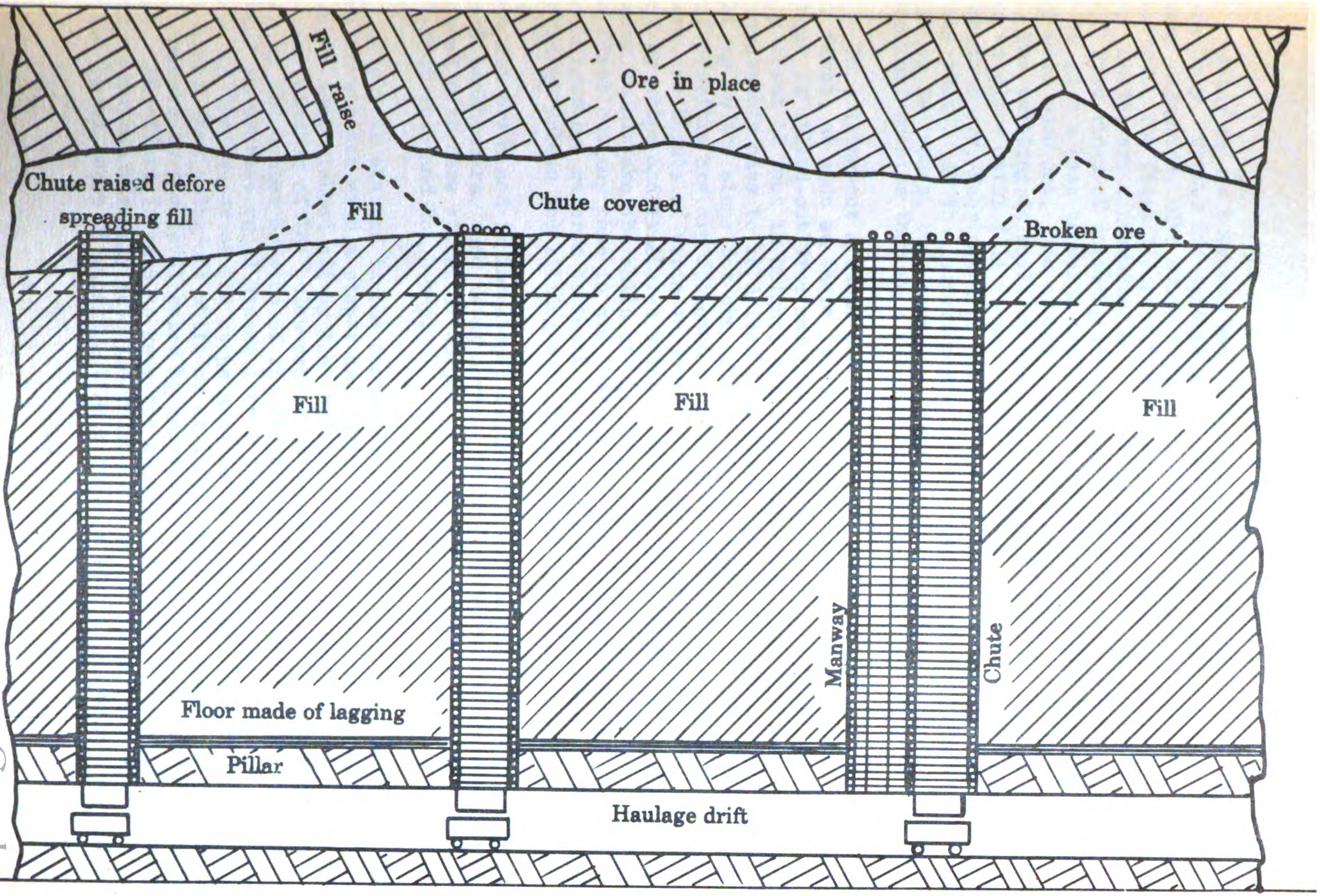


Figure 4.– Longitudinal section through stope, showing cut-and-fill mining. Not drawn to scale

STOPES

After an ore body has been located, a drift is run on ore the length of the ore body. Chutes are spotted at 50 foot intervals, and every third chute has a manway alongside. The chute raises are carried up about 20 feet and silling-out is started. The first floor of the stope is 14 feet above the floor of the drift below. Chutes are constructed of 10-inch round timber with 3-inch pine floor and sides. Five rings of cribbing are placed in each chute below the floor of the stope to give a base to build from, as the stope is taken up and the chutes are raised with each cut. The cribbing used is 8-inch round pine framed on the surface. The cribbing is built up without the use of nails, the tongues holding the pieces in place until fill is packed around the cribbed-up raise. Arc-shaped, iron chute doors, fabricated in Havana, are used to control the flow of the ore from the chute. As the largest pieces of ore coming from a chute are not larger than 12 or 14 inches, the doors have proved a great saver of time. Figure 4 is a longitudinal section through a cut-and-fill stope.

In silling-out a stope the hanging wall and footwall of the ore body are sought first, as soon as there is enough room to work. When the walls are found, the stope is silled-out from end to end. This first, or sill floor cut, is usually about 12 feet in height; all stope backs are flat. If the stope sills-out wide, crosscuts have to be driven from the drift below to allow more raises to be brought up to the stope for ore chutes. On the first cut all stringers and showings of possible ore are followed to make sure that all ore has been silled out. As there are horsts of waste in some of the ore bodies, and as the ore bodies are cut by slips and fractures which have caused little or no displacement, it is very easy to mistake the walls of the slips for ends of the ore body. Consequently the first cut may take in ore that is too poor to mine as the stope goes up. As the largest ore reserve estimate is made from the first floor, the estimate will be too large unless the silling-out of the stope is carefully watched.

All ore mined in the stopes is drilled with hand-rotated dry stopers and 48-pound jackhammers, both using seven-eighths-inch solid square steel. The holes are loaded with five sticks of 30 per cent gelatin dynamite and are fired by means of a 7-foot fuse and No. 8 cap.

A cut is started in the center or end of the stope, depending on its size. The cut is started with a stoper and carried through with jackhammers. Most of the ore is then slabbed off by flat holes drilled with jackhammers. The number, depth, and placing of the holes depend on where the round is being drilled, whether in the center or side of the stope, and the nature of the rock being drilled. An average round breaks from 8 tons along the sides to 15 tons when the round is in the center of the stope and the back is good. All holes are blasted by the miner when going off shift or at lunch time. All broken ore is placed in the ore passes to the level below by shoveling direct into the raise or by wheelbarrows. An effort is made to keep the chutes close enough together so that the ore can be mucked directly into the raise, but sometimes after a stope is halfway up to the level above it widens out or becomes a little longer and necessitates the use of wheelbarrows. The ore is hard and breaks comparatively small. All pieces over 12 inches are broken either by hammer or bulldozing before they are put into the raise.

Four-hour carbide hand lamps are used in the stopes; they are used every where in the mine.

While the stope is being silled-out, fill raises are run from the stope the level above. Formerly when surface fill (brought from centrally located glory holes on the surface to the different stopes by means of raises), as well development waste, was put in the stopes, it was the practice to drive the fill raises at 80-foot intervals. During the past year and a half the surface fill h been dispensed with and de-slimed mill tailing used in its place.[3] Due to the ease in handling the tailings, known locally as "sand fill," fill raises at 100 to 150-foot centers are sufficient. At least one raise to the level above is equipped with ladders, and in the larger stopes two or three raises are so equipped. All cribbing and timber for use in the stope are thrown down a fill raise from the level above. Machines, drill steel, and other supplies are take in and out of the stopes by the stope crew.

With one exception, no stopes have required square-sets on the first or sill floor. Ordinarily the only timber used in the stopes for 70 or 80 feet ab the level is the cribbing for the ore passes and manways and the plank lining f the ore passes. However, in a number of ore bodies the ore has been so fractur that these stopes require square-set timber. After a stope has been carried u to within 15 or 20 feet of the level above, square-sets are always used. All s are filled as soon as a cut is completed. This permits carrying the stopes up past the level and removing the ore from the level pillar of the stope above. While the removal of the level pillars from below the smaller stopes causes no trouble, as a rule the removal of a pillar from beneath a large worked-out stop causes enough subsidence to prohibit efficient tramming through the old drifts below the stope. If there is no haulage drift in the footwall of the stope, on is then driven before the pillar is removed. During 1928 approximately 30 per cent of the total mine ore came from square-set stopes.

When a stope has been completely silled-out, the first cut taken, and a floor of hardwood slabs and poles laid down, it is ready for fill. On an avera after a cut has been taken the back is 12 feet above the floor, and 6 or 7 feet fill is placed in the stope. Before the fill is put into the stope the ore pas to the level below are cribbed up to the required height. If development wast is used, it is dumped down the fill raises and spread in the stope either by shovel, shovel and wheelbarrow, or by scraper. Part of the contract crew sprea the fill; the contractor is paid 20 cents for each ton of fill spread by hand a 5 cents per ton for fill spread by scraper. The scrapers are operated by means of double-drum tugger hoists. Due to the care the hoist must have, the necessi of changing the hoist to keep it lined with the cable, etc., the scrapers have not proved popular with the men.

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[3] Richert, G.L., Filling Stopes with Mill Tailings. Eng. and Min. Jour., Mar. 1929, p. 348.

At present one-half the fill tonnage is made up of sand fill. The amount of sand fill used depends entirely on the amount of development waste that must be disposed of as fill.

Briefly, the sand-fill system consists of pumping mill tailings to a 30-foot bowl classifier situated on the surface near a raise leading into the mine. Figure 5 shows diagramatically the Matahambre system of filling stopes with mill tailings. The slime overflow from the classifier is sent to the tailings pond, and the rake product drops into a hopper. Water is added to the hopper and the course tailings are washed into a 2 1/2 inch special rubber-lined pipe. This pipe is strung through a line of raises from the surface to the 1,200 level. The sand fill is taken through the pipe to the stope to be filled. Before the stope is filled, the cribbed up raises and manways are wrapped with a commercial grade of burlap to prevent the sand from washing out between the cribbing. By means of pipe or hose the sand is directed wherever wanted. By building up small sand dams it is possible to fill any part of the stope. After 12 hours the water has seeped out through the burlap into the ore passes, and the floor of the stope is almost as hard as ordinary soil. After two years of experimenting it was found that rubber-lined pipe was best for handling this fill. Standard pipe, extra heavy pipe, and special rubber hose were tried, but the rubber-lined pipe proved to be the best. The advantages of this filling system are ease of handling, no spreading, a sufficient amount of fill always available, the fact that the fill can be changed from a stope in one end of the mine to a stope in the other end of the mine by breaking and making a few pipe connections, and the fact that the sand enters all cracks and fissures and forms a solid pillar between the walls of the stope.

UNDERGROUND TRANSPORTATION

All ore hoisted to the surface is loaded into the skip from pockets on the 800 to 1,200 or 1,500 levels, or by dumping cars directly into the skip on the 1,600 and 1,700 foot levels. The installation of an ore pocket below the 1,800 level is 75 per cent complete. When this is finished the ore from the 1,600, 1,700 and 1,800 levels will be handled through this pocket. On the 600, 700, 800, 900, 1,000, and 1,100 levels, the ore from the north part of the mine is sent through ore passes to the 1,200 level, where it is taken to the station and pocket by motor train. The ore near the shaft and the south part of these levels is trammed by hand to the ore passes or pockets at stations. All cars are 20-cubic-foot capacity, end-dump, and have roller-bearing wheels. On the 1,200, 1,300, 1,400 and 1,500 levels the ore is taken to the station by small storage-battery "trammers" or locomotives pulling from six to eight cars. As the grade is with the load, the length of the train is not dependent on the loaded cars that can be handled, but on the number of empties that can be taken back against the grade. There are six of these motors underground and one operating on the surface hauling supplies and timber from the tram terminal. The average duty of the motor is 8 hours; a crew of two men is required, and an average trip of 1,200 feet is made, hauling 100 to 150 cars of ore per shift. The brakeman assists in loading, or loads the cars from the chutes below the stopes. All motors are brought to the surface at the end of each shift, the batteries are changed, and the motors are sent back for the next shift. Only on special occasions are motors worked on three shifts.

The mine is 90 per cent equipped with arc-shaped iron chute doors. Those used in the chutes below the stopes are 30 inches long, whereas those used on chutes in ore passes between levels or leading to the skip pockets at the stations are 40 inches long.

On the levels above the 1,700 level, the track is 18-inch gauge and 18-pound rails are used. Below the 1,700 level the track is 18-inch gauge and 24-pound rails are used. Grade is carried at plus one-half of 1 per cent going from the shaft.

PERCENTAGE OF EXTRACTION

The limiting factor in the percentage of extraction in square-set stopes at Minas de Matahambre is the price of copper. In straight cut-and-fill stoping practically all mineral-bearing rock is removed. When square-sets are used, the cost of timbering makes it necessary to leave some of the low-grade material which is not worth extracting. For this same reason it is sometimes not economical to extract low-grade portions of pillars. As stated previously, on the first or sill floor every effort is made to get all the ore in sight to make sure that the stope has been completely silled-out. Consequently, when a stope comes up under a pillar and square-sets are used, in many cases not all the ore that was silled-out above the pillar will pay to square-set. However, as over 90 per cent of the estimated ore (from ore reserve estimates) is recovered,- the other 10 per cent includes overestimation, and loss by caves and all other causes - the amount of ore left or lost is small.

No waste is sorted on the surface, although high-grade ore is sorted on a picking belt. However, sorting of waste is carried on underground in all the stopes. This applies especially to stopes with ore below average grade which are being mined with the expectation that they will eventually improve and come up to grade. If the waste is sorted conscientiously and piled up where it can be measured, it is sampled, measured, and paid for at 5 cents per ton more than the miner received for his ore. Before this practice was instituted, it was thought that the miners would shoot down everything in sight and pile it up for waste but it has not worked out that way. Car checkers count the cars and examine the ore at the station. The contractors are paid on a "per car of ore" basis, and any cars containing large proportions of waste are not paid for.

VENTILATION - NATURAL AND MECHANICAL

Before the installation of the fans the mine had a fairly efficient natural ventilation system.[4] Aside from raises to glory holes, two lines of raises had been run from the 1,300 level to the surface and one line from the 700 level to the surface. Two of these lines of raises are single compartment, 5 by 6 feet, and the other is a double compartment raise 5 by 10 feet. The single compartment raises were used as manways and for ventilation. The double compartment raise carried the sand-fill pipe line and was also used for ventilation. In addition to these raise connections to the surface, the north part of the Matahambre mine has been connected on nearly all levels to the Ruiseñor, a north extension of the Matahambre.

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[4] Richert, G. L., Mechanical Ventilation at the Minas de Matahambre. Min. Cong. Jour. July, 1928, p. 491.

The Ruiseñor levels are connected to the surface by a double compartment raise which is naturally downcast. This natural ventilation makes the main shaft and the Ruiseñor raise downcast, while the three raise lines to the surface are upcast. This condition has not been changed by the addition of the fans. Although the natural ventilation removed the gas and smoke after blasting, the heat and humidity in practically all parts of the mine was oppressive.

In April, 1927, Mr. Charles A. Mitke made a study of the mine ventilation and found that temperature and humidity conditions were as follows:

Temperatures underground ranged from 71 to 93° and in the majority of places were over 80°. There was almost complete saturation of the air in the mine due to water in the shaft and in the drifts. Air with surface humidity of 46 per cent entered the 1,200 level 96 per cent saturated. At Mr. Mitke's suggestion three fans, each of 45,000-cubic-foot capacity, driven by 50 hp. motors and operating against a minimum of 3 1/2-inch water gauge, as suction fans were installed on the surface over three of the raise lines.

In addition to the fans the necessary bulkheads, doors, and runarounds, were installed to direct the air properly through the mine. This arrangement increases about six times the amount of air, approximately 21,000 cubic feet per minute, which entered the mine by natural ventilation. It was estimated that the mine shaft, as an intake, would supply 72,000 cubic feet of air per minute, the Ruiseñor raise connection 6,000 cubic feet per minute, and other raises with surface connections would supply the remaining 27,000 cubic feet, while the three fans with a capacity of 45,000 cubic feet each would exhaust 135,000 cubic feet per minute.

While temperatures have not been materially reduced, the increased volume and velocity of the air through the mine has (1) bettered the morale and spirits of those employed underground; (2) speeded up the work, especially tramming; decreased the rate of decay of timber, especially in the main haulageways to the shaft, for the fungus and "cotton" have practically disappeared.

WAGE, CONTRACT, AND BONUS SYSTEM

All labor at Minas de Matahambre, with the exception of the staff, is hired at the mine. Contrary to general opinion, there are very few Cubans employed underground. The Cubans are by nature farmers and do not care to work underground. The mine labor is made up of Spaniards, Russians, and men of other central and southern European nationalities; there are at least 27 nationalities represented on the payroll. The Spaniards, many of whom have worked in the mines in Spain, are good miners and make good contractors and bosses. Some of the Russians have also had mining experience and make good contractors and timbermen. However, probably 60 per cent of the underground labor have not had previous underground experience. This causes a shortage of good machinemen, as most of these men must be taught to drill. The others readily adapt themselves to mucking and tramming. All in all, the underground labor at Matahambre is much better than the general run of mine labor in tropical countries.

Company wages are $3 for timbermen, $2.50 for miners, $2.25 for motormen and timbermen's helpers, and $2 for muckers and trammers. All work underground is done by contract, and all contractors are guaranteed company wages.

A stope contractor has charge of the stope where he is working, or in larger stopes where there are two or three contractors, he has charge of and is responsible for only a certain part. The contractor is paid a fixed price for all work done and is charged for fuse, caps, dynamite, carbide, and his men's time. The men working for the contractor are paid by the company at company wag
Average prices paid in stopes are:

	Price
Ore per car	$0.60 to .70
Spreading fill	.20 to .30
Square-set timber, per piece	.75
Cribbing, per piece	.15
Slabs laid on the first floor before fill is placed in the stope	.10
Lagging and planks	.10
Hand-sorted waste (per ton)	.75
Chutes, single	12.00
Chutes, double	15.00

The company furnishes the timbermen to put in the chutes, and the contractor is charged with their time.

All timber and material must be taken from the shaft station to the sto by the contractor's men. Each contractor has an "associo" who is in charge of other shift, and who shares equally with the contractor in the money.

On drift contracts there are four men, the contractor and his "associo" both are miners - and two muckers or helpers. The average price paid for drift is from $12. to $18 per meter, depending on the nature of the ground. The contractor is charged with helper's wages, as well as with the dynamite, fuse, cap and carbide.

Raise contracts have four men - two miners and two helpers. The averag price paid for raises is $12 per meter for a single raise in ore, 75 cents for each car of ore, and $15 per meter for a single raise in waste. Special raise for ore passes, and those requiring timbering are at special prices ranging fr $15 to $22 per meter. It was found that unless a raise man was paid for ore, he was driving in ore, he turned the ore in at the station for some stope contractor. Under the present system his raise price drops when he is in ore and must turn his ore in under his own name to receive pay for it.

All work is measured by the engineering department twice a month, on t 15th and 30th. The men are paid only once a month, although they may draw par their money each Saturday. The measurement on the 15th is carried through the same as at the end of the month. All money earned and all charges are put on contract statements. This gives the mine superintendent a chance to see how t work is going, and who is and who is not making money. He then has a chance to find out the reason and to try to remedy matters. As the majority of the labor can neither read nor write, the thumbprint made with ink from a stamp pad goes as a signature. Everything on the contract sheets must be as simple as possible, for these men are dependent on those who can read for an explanation of their contract statements.

A speed bonus is in effect for drifting and crosscutting. Any contractor who drives 70 feet of drift in one month receives $1 extra for each meter driven, for 85 feet $2, for 100 feet $3, and for 115 feet $4 extra. No one has made the 115-foot mark as yet, although a number have made more than 100 feet. A raise bonus in force adds $3 per meter to the price of a raise after it is 50 feet vertically above the starting point. From July, 1927, until October, 1928, a general bonus system was in effect in which all participated. Under this system a stope contractor and his "associo" were allowed to make $3 per shift worked before paying a bonus to the men. If more than $3 per shift was made, 40 per cent of the money over $3 was divided between the contractor and his "associo" and 60 per cent between the men working for him. In drifts and raises the base pay was $2.50 per shift. If more than $2.50 was made, 60 per cent of the amount over $2.50 was divided between the contractor and the "associo" and the remaining 40 per cent among the men according to the shifts each had worked. This system was not entirely satisfactory; at the present time after the contractor has earned his maximum wage allowance before bonus distribution, both contractor and men participate equally in the bonus, in proportion to the number of shifts each man has worked.

FIRE HAZARDS

The fire hazards underground are few, but they are carefully guarded against. The main shaft, which is downcast, is comparatively dry from the surface to the 700 level, a distance of 244 feet. Below the 700 level the shaft is wet and not likely to burn. Due to the high humidity in the mine all timber in the drifts is damp and would be very hard to set afire. However, to eliminate as much as possible any likelihood of the occurrence of fire underground, no rubbish or trash is allowed to accumulate in the mine. As a means of handling a fire, if one should start, 50-foot reels of standard fire hose connected to a 2 1/2-inch pipe line are placed at the collar of the shaft and on the 600 and 700 level stations. The pipe line is connected to a fire pump that is hooked up to draw from an 8,000-gallon storage tank or from the main camp reservoir supply line. A fire line, 2 1/2-inch pipe, with hose boxes and hose at suitable intervals, has also been placed on the surface to protect the surface buildings and the timber yard. In addition to the hose on the 600 and 700 levels, chemical fire extinguishers have been placed in all powder magazines and at the pump stations on the 900, 1,300, and 1,700 stations. Because the shaft is naturally downcast, wooden doors faced with metal, having thei frames set in concrete, have been placed on all levels as near the shaft as possible; the average distance from the shaft is 150 feet. If there is fire in the shaft, these doors can be shut and so protect the levels from smoke and gas. As a warning signal to the men underground in case of fire, there is also on the surface a Mercaptan tank and feeder. The feeder is connected to the main air line going down the shaft. A standard set of fire rules have been drawn up and posted in conspicuous places. These rules give specific directions as to the handling of the fire fighting equipment on the surface as well as underground, depending on the location of the fire, where to go and what to do, when to shut down fans, and whom to notify first. As there are a telephone exchange and two timekeepers in the mine office, 50 feet from the shaft, most of the first work would fall to them. The company has recently purchased six McCaa two-hour breathing apparatus. As soon as possible a crew will be trained to use this apparatus under direction of men trained by the Bureau of Mines.

SAFETY METHODS AND FIRST AID ORGANIZATIONS

An active safety first organization has been in operation at Minas de Matahambre since the latter part of 1927. The organization consists of a general safety committee and several local committees. All committees meet every other week. The general manager acts as the chairman of the general committee and the safety engineer acts as the secretary. The members of the general committee are the heads of the different departments and their assistants. The chairman of each local committee is the head of the department represented, and the members are chosen from the men working in that department. The members of the local committees are paid $1 for each meeting attended. The members of these committees are changed every three months. Local committees have been organized in the mine, mill, surface, machine shop, power plant, and dock departments. The business of the general committee is to discuss safety-first problems. The business of the local committees is the actual instruction of the men on the job in the matters of safety and first aid. To help keep up the interest in this work the company has supplied "committee" badges for the members of the local committees, pins for one year's service without accident, instruction and rule books which are given to eac man when he goes to work, a "safety flag" which is flown over the department having the smallest number of accidents for one month, a glass-enclosed and electrically lighted bulletin board, with signs and posters, and a large clock with one hand, the hand pointing to the number of days the mine has worked without an accident. In addition a bonus of $15 is given each shift boss in the mine having a record of 1,000 man-shifts without a lost-time accident and a bonus of $25 is given for each succeeding 1,000 shifts without an accident. There are special prizes consisting of a $125 watch for the mine-shift boss having the least number of accidents during one year, $50 for the second best record, and $25 for the third best record.

Some changes and improvements that have been made as a result of the activities of the safety first organization are:

1. A reduction of about 60 per cent in the number of accidents.

2. The use of leather shoes instead of canvas slippers by all men working for the company.

3. The installation of first-aid boxes on all levels of the mine. Each box contains bandages, gauze, cotton, and a bottle of mercurocrome. There is also a Stokes wire stretcher on all stations in the mine and in all plants on the surface.

4. Maintenance of the fire prevention and fire fighting system and apparatus previously described.

5. The provision of electric lamps for use in magazines in case the power goes off.

6. The use of "hard-boiled hats."

7. The use of screen goggles by all men breaking rock.

8. The use of separate canvas sacks for carrying dynamite and capped fuse to the working places.

9. The covering of all unused raises in the stopes and of raises and ore passes in use with grizzlies made of steel rails.

10. The changing of all open electric switches on the surface and underground for closed types of switches.

11. The guarding of all machinery on the surface as well as in the mine by use of guards over gears, etc.

12. A general "safety first - watch your step" spirit or attitude in all employees.

TABLE 1 - SUMMARY OF COSTS

Name of mine: Minas de Matahambre, S. A. Period covered: Jan. - Dec., 1928.

Tons of ore hoisted during period: 364,746 short tons

Mining method: Cut-and-fill and square-set.

Underground costs per ton of ore hoisted

	1 Labor	2 Super-vision	3 Compressed-air drills and steel	4 Power cost	5 Explos-ives	6 Timber	7 Other Supplies	8 Tot
Development: In rock	$0.334	$0.060	$0.067	$0.009	$0.105	$0.077	$0.059	$0.
Mining	.559	.095	.085	.005	.095	.192	.059	1.
Fill	.134	- -	- -	.003	- -	- -	.040	.
Transportation (underground) ...	.281	- -	.005	.035	- -	- -	.067	.
General under-ground expense ..	.106	- -	.004	.035	- -	- -	.039	.
Total	1.414	.155	.161	.087	.200	.269	.264	2.
Surface expense (directly appli-cable to under-ground operation)	.019	- -	- -	- -	- -	- -	- -	.
Total	1.433	.155	.161	.087	.200	.269	.264	2.

TABLE 2 - SUMMARY OF COSTS IN UNITS OF LABOR, POWER, AND SUPPLIES

Name of mine: Minas de Matahambre, S. A. Period covered: Jan. - Dec., 1928.

Tons ore mined and hoisted: 364,746. Mining method: Cut-and-fill and square-set.

	Development	Mining (stoping)	Total
A. Labor (man hours per ton):			
Breaking (drilling and blasting) ..	0.38	0.69	1.07
Timbering and filling	0.11	0.67	0.78
Mucking	0.51	0.92	1.43
Haulage and hoisting	- -	0.64	0.64
Supervision	- -	- -	0.11
General	- -	- -	0.28
Total	1.00	2.92	4.31
Average tons per man per shift	8.00	2.74	1.86
Labor, percentage of total cost ..	19.91	39.87	59.78
Av. tons per man-shift on surface properly chargeable to underground operation	- -	- -	211.71
B. Power and supplies per ton:			
Explosives (lbs. per ton)	.58	.44	1.02
(kind and grade) gelatine	- -	10%-30%-40%	- -
Timber (framed, b.m.)	.344	.802	1.146
(props, pcs.)	.023	.125	.148
Power (kw.h. per ton)			
Air compression	3.50	4.50	8.0
Hoisting	- -	3.00	3.0
Pumping	1.03	.76	1.79
Ventilation	- -	1.22	1.22
Total	4.53	9.48	14.01
Other supplies in percentage of total supplies and power	11.27	16.13	27.40
Supplies and power, percentage of total cost	16.05	24.17	40.22
C. Percentage of total cost	35.96	64.04	100.00

Note: Figures for development and mining are both based on total tonnage produced rather than on ore produced from development and mining respectively.

TABLE 3 - DETAILS OF COSTS IN UNITS OF LABOR, POWER, AND SUPPLIES

	Sinking	Drifting	Cross cutting	Raising
Size of excavation	17 x 8 ft	5 x 7 ft	5 x 7 ft	5 x 5 ft
Timbered or not	Yes	10%	10%	1%
Physical properties of rock	Hard and firm in quartzite Soft and loose in shale			

	Total development
A. Labor (man hours per foot):	
Breaking (drilling and blasting)	3.26
Timbering	1.38
Mucking	6.61
Other labor	1.00
Total labor	12.25
Feet per 8-hour shift	0.65
B. Power and supplies (per foot):	
Explosives (lbs. per ft.)	7.48
Timber (per ft.)	$1.07
Total power (kw.h.):	
Air compression	45.4
Hoisting	- -
Haulage	- -
Ventilation	15.9
Other supplies	$1.17
C. Labor (percentage of total cost):	55.3
Power and supplies (percentage of total cost)	44.64

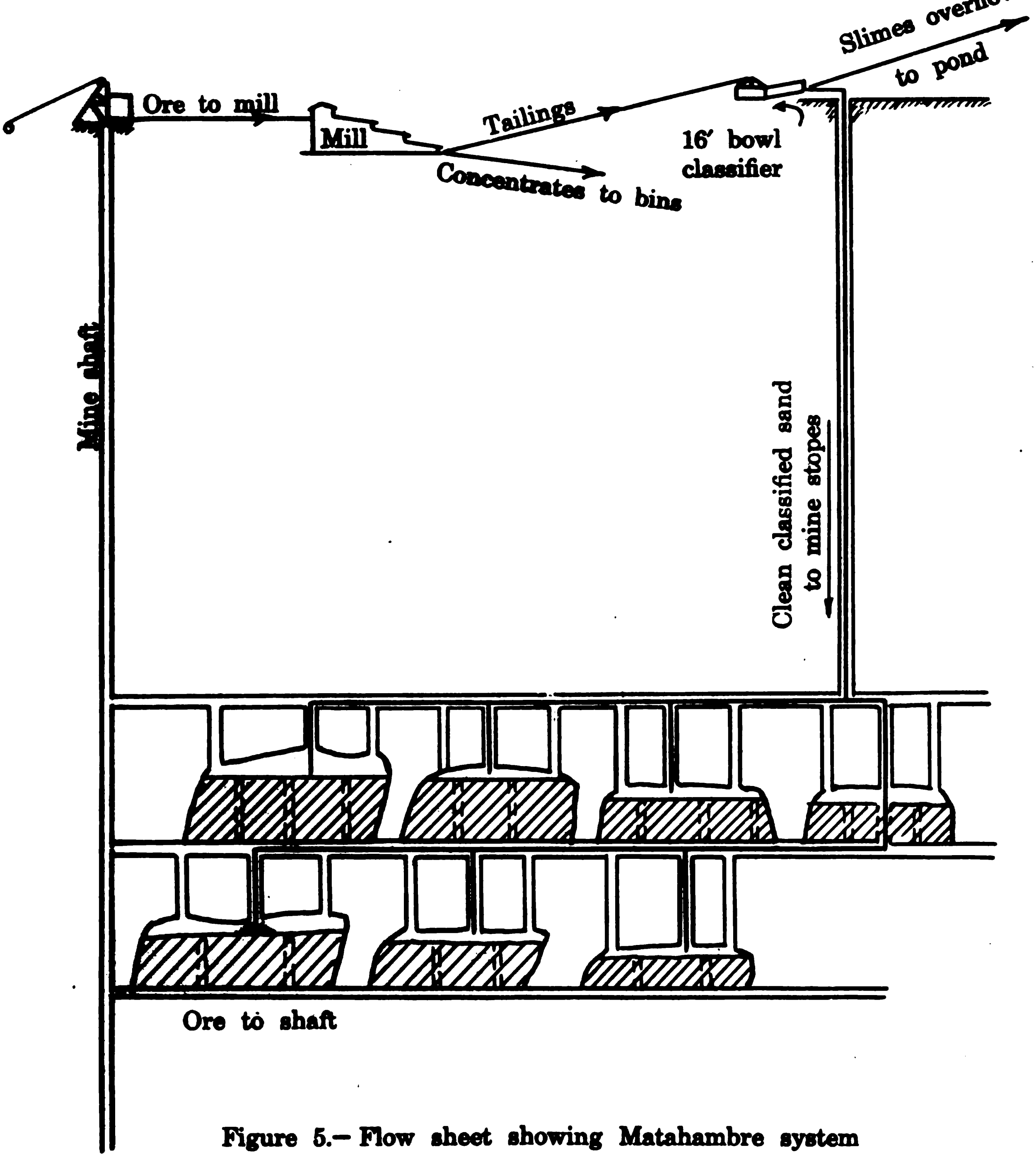

Figure 5.– Flow sheet showing Matahambre system of filling stopes with mill tailings